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READINESS AND IMPLEMENTATION STUDY FOR A REUSABLE AMMUNITION RE--ETC(U)

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**NAVAL WEAPONS HANDLING
CENTER**

TECHNICAL REPORT

**READINESS AND IMPLEMENTATION STUDY
FOR
A REUSABLE AMMUNITION RESTRAINT SYSTEM
IN
COMMERCIAL INTERMODAL CONTAINERS**

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The results of the study indicate that a plan (herein described as Scenario V) which encompasses maintaining an inventory of complete restraint systems as well as production of new restraint systems during the contingency would be most suitable.

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READINESS AND IMPLEMENTATION STUDY
FOR A REUSABLE
AMMUNITION RESTRAINT SYSTEM
IN COMMERCIAL INTERMODAL CONTAINERS

ABSTRACT

This report describes a study conducted of implementation and readiness options applicable to a reusable mechanical system for restraint of ammunition during transport in 8' x 8' x 20' commercial intermodal containers as developed by Naval Weapons Handling Center (NWHC), WPNSTA Earle. As part of the study, elements such as lead time stockpiling, inventory size, reusability, production during the contingency, and others are discussed. The interaction and relationship between these elements is demonstrated by means of scenarios constructed to include these elements.

Those scenarios constructed so as to provide readiness from the outset of the contingency and full implementation throughout, have two extremes of initial sources. These are (1) in-contingency production (without any inventory of complete restraint systems) and; (2) a large inventory of complete restraint systems (without in-contingency production capability). In addition, several scenarios are presented which are dependent upon both an initial inventory of restraint systems plus in-contingency production.

The results of the study indicate that a plan (herein described as Scenario V) which encompasses maintaining an inventory of complete restraint systems as well as production of new restraint systems during the contingency would be most suitable.

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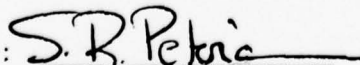

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I. BACKGROUND AND INTRODUCTION

It has been heretofore established that in the event of a military contingency, the throughput of ammunition in 8' x 8' x 20' intermodal containers will be in the order of 1,000 container loads per day. Since the present number of serviceable US Army MILVANS (estimated at 4,000 units) would suffice only for several days at that rate, the large inventory of commercial containers must be employed. However, in order to utilize these commercial containers, an approved method of ammunition restraint (self-contained in MILVANS) needed to be devised. Several methods have been developed including the reusable INTERNAL RESTRAINT SYSTEM KIT (IRSKIT) as described herein developed and tested by the Naval Weapons Handling Center (NWHC), WPNSTA Earle, Colts Neck, New Jersey.

NWHC originally intended to develop IRSKIT consisting entirely of "off-the-shelf" hardware. Several prototypes using this approach were tested satisfactorily. However, as technical progress was being made, indications were that departures from "off-the-shelf" should be made for several reasons. First, "off-the-shelf" hardware imposed constraints on other design goals such as maximum use of cube, simple installation, and minimum interference with stuffing and unstuffing operations. Secondly, during initial phases of the development, throughput requirements had not been fully defined. As the program progressed, these requirements for a contingency were determined and information was gathered as to availability of supposedly "off-the-shelf" hardware in large quantities. It appeared doubtful whether adequate amounts of components could be obtained to support large shipments.

Therefore, it was deemed appropriate to continue the development utilizing basic materials which are readily procured or have short procurement lead times, and which could be subsequently modified for IRSKIT. The purpose of this study then, is to examine the aspects of contingency implementation and preparedness with regard to quantity, material acquisition, and modification requirements. Proposed scenarios have been constructed to represent extreme or moderate level of preparedness and implementation.

These scenarios are the basis for calculations which yield coefficients useful in a comparative ranking system for the proposed scenarios.

II. THE RESTRAINT SYSTEM (IRSKIT) DESCRIPTION

The lading is restrained within the container by a system consisting of the following components (figures 1 and 2):

- a. Four 5/8-inch diameter steel wire rope assembly.
- b. Four steel anchor blocks.
- c. Four 1-inch diameter x 48 inches long rod with 1-8 UNC-2A threaded ends.

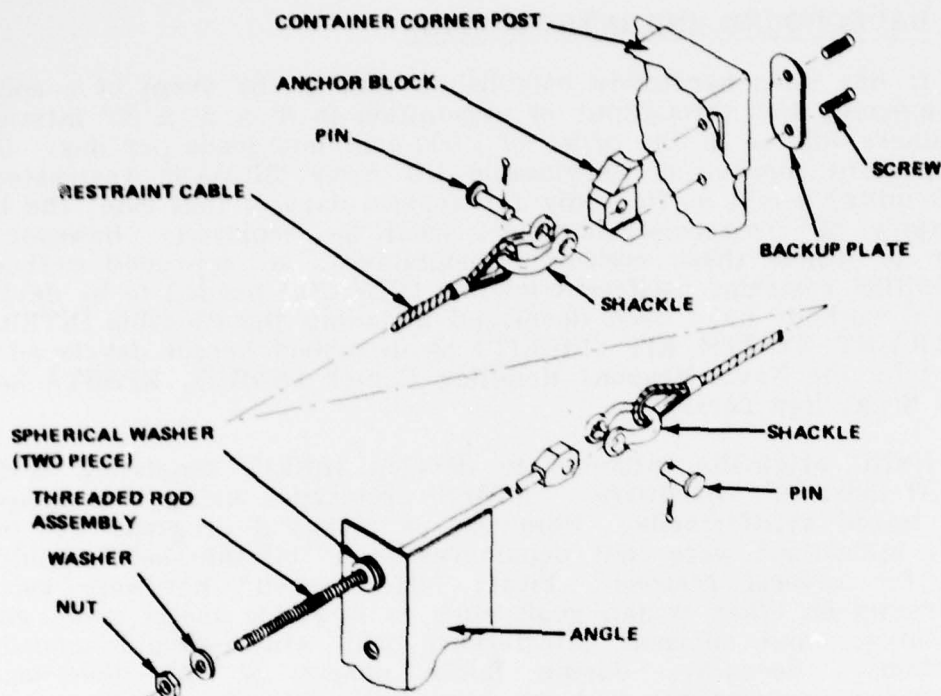


Figure 1. Details of IRSKIT Hardware.

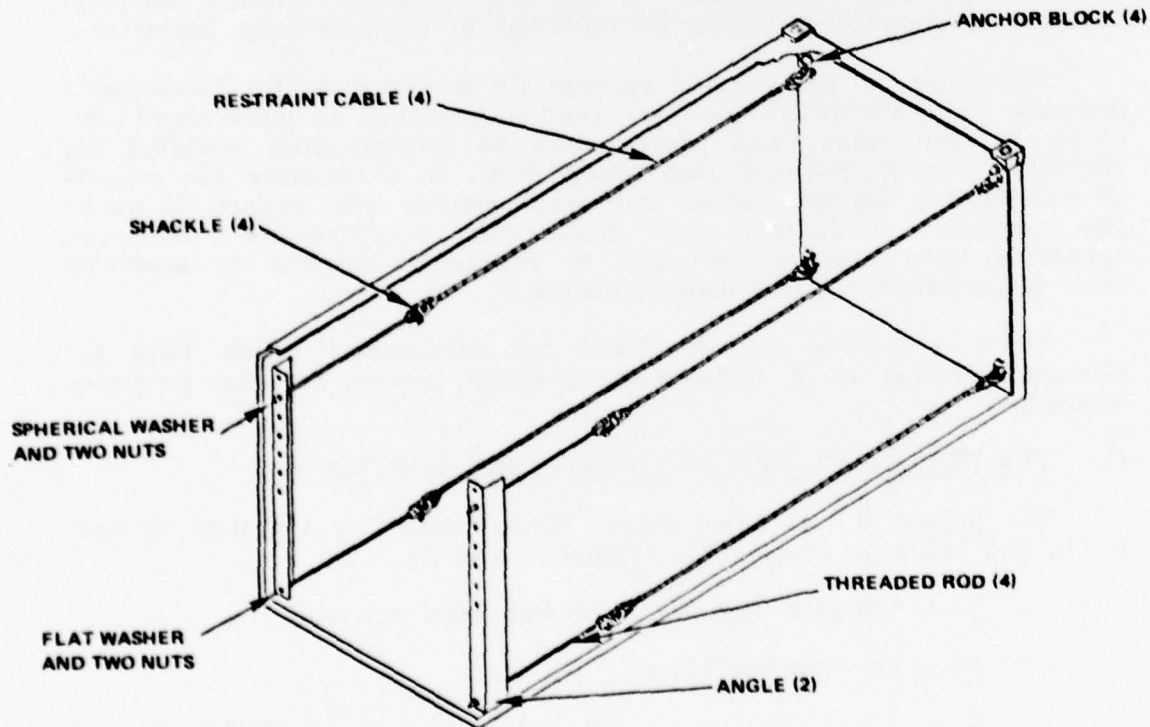


Figure 2. Typical IRSKIT Hardware in Commercial Container.

- d. Four backup plates.
- e. Two aluminum structural angles 8 L 12 x 85 inches.
- f. Two spherical washer pairs.
- g. Miscellaneous hardware.

Each structural angle has a series of predrilled holes for the purpose of attachment to the restraint cable assembly (wire rope, shackles, and steel tie rod assembly). Each upper tie rod assembly is installed through that hole which lies immediately above the level of the ordnance lading. Selection of the appropriate hole results in the restraining forces being applied at the location of maximum effectiveness for a wide range of cargo lading heights.

The spherical washer arrangement provides the nut at the end of each upper threaded rod with a flat bearing surface regardless of the angle which the cable assembly and structural angle may assume due to lading height.

Since spherical washers are capable of compensating for limited amounts of misalignment, it is necessary to spotface the structural angles to an additional small angle.

Each lower restraint cable assembly is installed through a single hole located at the lower end of each structural angle. There is no alternate hole installation for the lower cable assemblies. Since these lower cable assemblies will always be horizontal and perpendicular to the structural angle, there is no need for alignment devices as used with the upper cable assemblies.

Attachments to the container corner posts are accomplished by means of the anchor blocks, backup plates and countersunk screws.

The only container modification required prior to installation of the IRSKIT consists of drilling eight 7/8 inch diameter holes in the corner posts at the front (closed) end. The holes accommodate the terminal connections (anchor blocks, backup plates, and screw) of the restraint system.

III. SCENARIO BASELINE

A. Terminology. The following terms are used extensively through this study:

- a. Tooling - Equipment (i.e. jigs, fixtures, dies and molds) and processes (i.e. heat treating, plating and welding) required to convert "Material" into complete "Kits". Tooling must be fully developed and capable of achieving the desired production rates.

- b. Materials - Stockpile or stabilized sources of major components, as produced by mills, and/or stocked by warehouses. For IRSKIT these would be aluminum angles, spools of wire rope, billets of steel for castings, forgings, and machined parts.
- c. Kits - All components ready for implementation as a mechanical restraint system.

B. Estimates and Assumptions. The estimates and assumptions listed below were required in order to construct the scenarios. Others will be introduced as necessary for specific purposes.

- a. Tooling lead time - 60 days (estimated)
- b. Material acquisition lead time - 60 days (estimated)
- c. CONUS depot to EX CONUS to CONUS depot - 30 day cycle time (estimated)
- d. 50% return rate of complete kit (estimated)
- e. Duration of contingency - 90 days (assumed)
- f. Sole source contracts to previously qualified vendors can be immediately placed - No procurement lead time required.

C. Matrix of Scenarios. From the definitions of paragraph IIIA above it is evident that the tooling and materials are considered as separate entities, and the "kits" are the end items. However, all three are capable of prestocking prior to a contingency. As will be shown, prestocking is a requisite of early implementation due to the lead time requirements. The scenarios will be discussed in detail, but are summarized in Table 1.

Table 1.

AT D-DAY	SCENARIOS							
	I	II	III	IV	V	VI ¹	VII ¹	VIII ¹
Tooling Available ²	NO	YES	NO	YES	YES	YES	NO	NO
Material Available	NO	NO	YES	YES	YES	NO	YES	NO
Kits Available	NO	NO	NO	NO	YES	YES	YES	YES

Table 1 (Continued)

Notes:

1. Scenarios VI, VII and VIII primarily illustrate implementation from inventory only without production capability (until D+60 for Scenarios VI and VII). Scenarios VII and VIII indicate availability of kits without the availability of tooling. However, the existence of kits in inventory presupposes a means of converting raw materials into complete kits, i.e. tooling. This will be referred to as "soft" tooling. Soft tooling may be further described as requiring no significant investment. Rudimentary equipment is used in conjunction with labor intensive methods, thus making soft tooling suitable only for accumulating an inventory over long periods of time. Hard tooling on the other hand, would be highly mechanized, integrated and capable of production rates related to throughput.
2. The amount of tooling required is related to the proposed or required production rate. This production rate in turn, may vary for each scenario and specific time frames during the contingency.

VI. SCENARIO DESCRIPTIONS AND IMPACT

A. Scenarios I, II, and III.

1. Description. There are no kits available from inventory. Scenarios II and III include the availability of either tooling or material but neither include both. However, the material acquisition lead time is identical to that for tooling; therefore the time flow charts are identical for each of these three scenarios (figure 3).

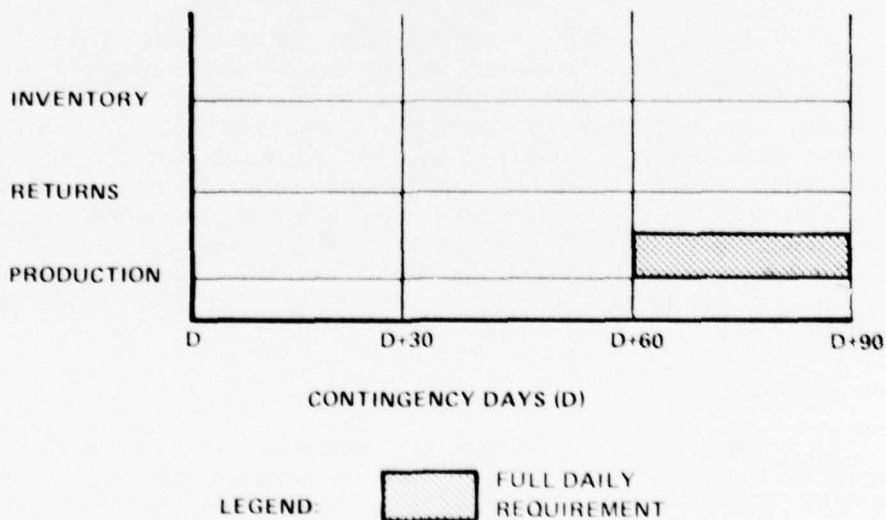


Figure 3 Time Flow Chart, Scenarios I, II, and III.

2. Impact. Kits not available until D+60. Prior to D+60 containerization must rely on other restraint methods. Also, since the container recycle time is estimated at 30 days, the reusability of IRSKIT will not be a beneficial factor in a 90 day contingency. The daily production rate is equal to the daily usage rate.

B. Scenario IV.

1. Description. Tooling and materials are available to begin production at D-day. No inventory of kits is maintained (figure 4).

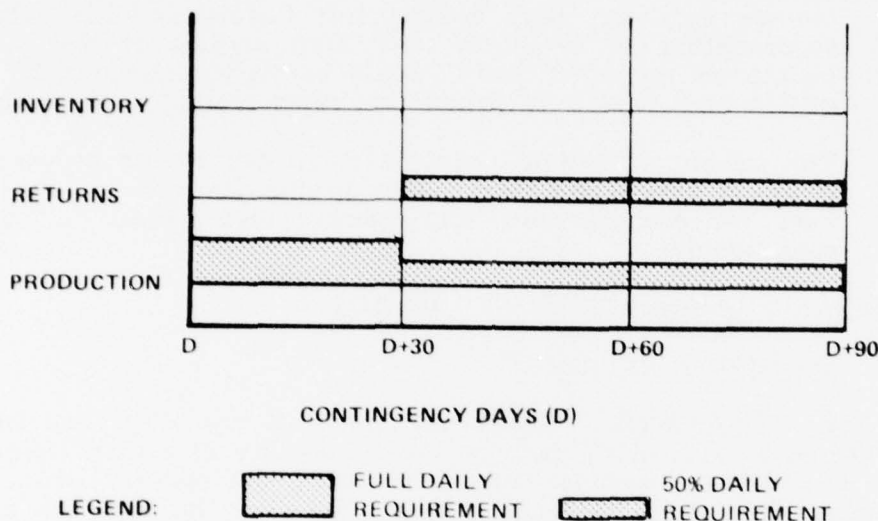


Figure 4. Time Flow Chart, Scenario IV.

2. Impact. Full implementation is possible from D-day. The daily production rate must be equal to the daily usage rate until D+30. At D+30 the recycled containers with restraint systems begin to supplement the kits from production thereby reducing the daily production rate requirements. Therefore, the minimum material stockpiled at D-day must satisfy 100% of the usage requirements from D-day through D+30 and 50% of the usage requirements from D+30 through D+60. Consequently, half of the tooling which was kept in readiness prior to D-day and required until D+30 becomes surplus. Materials must be ordered at D-day to ensure availability for production during D+60 through D+90.

C. Scenario V.

1. Description. Tooling and materials are ready to resume production at D-day. Hard tooling has been used prior to D-day to produce kits which are inventoried and ready for implementation at D-day (figure 5).

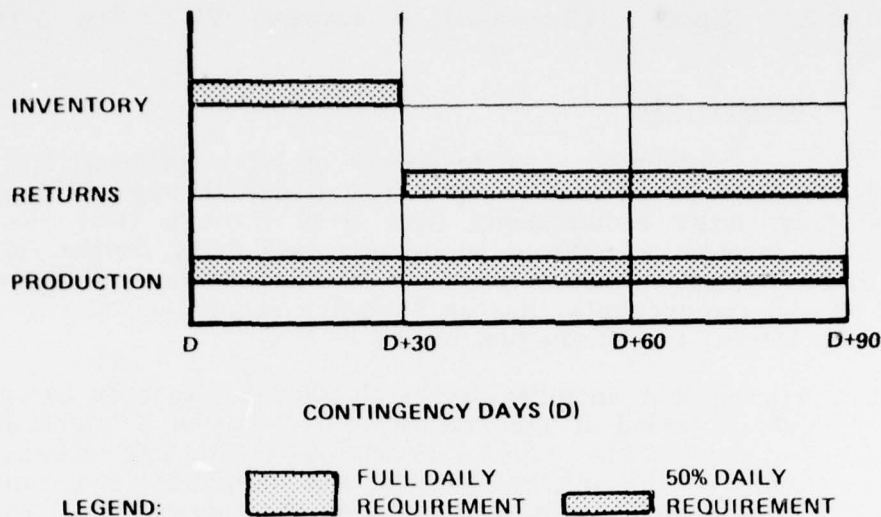


Figure 5. Time Flow Chart, Scenario V.

2. Impact. All usage requirements are available from inventory and production on D-day. The production rate remains unchanged throughout the contingency period. The material stockpile must be sufficient to support a daily production rate equal to 50% of the daily usage rate until D+60 in order to accommodate the estimated 60-day acquisition lead time. However, materials must be ordered at D-day to ensure availability for production during D+60 through D+90.

D. Scenario VI.

1. Description. At D-day, a sufficient inventory of kits is available in addition to the hard tooling required to begin production. However, the material stockpile for the production of new kits has not been maintained (figure 6).

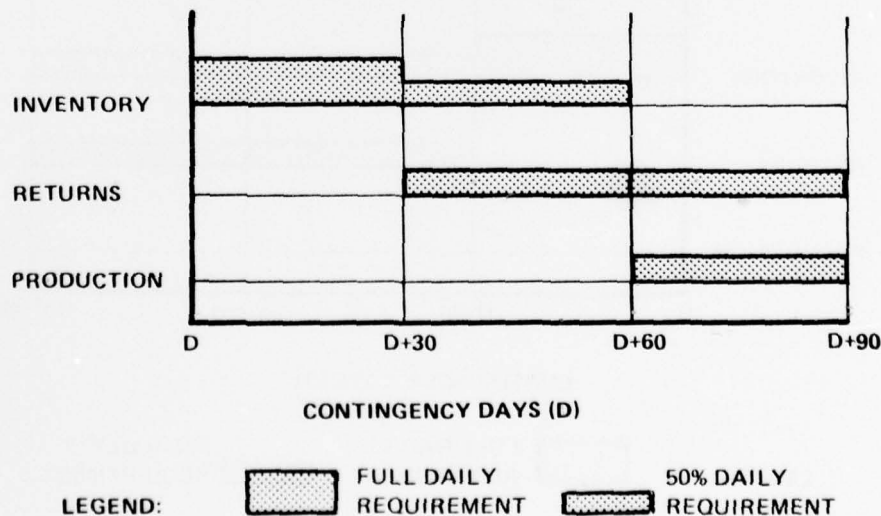


Figure 6. Time Flow Chart, Scenarios VI and VII.

IV.E.2) 2. Impact. (Discussed in scenario VII. See paragraph

E. Scenario VII.

1. Description. An inventory of kits, sufficient to support 100% of the daily usage requirements from D-day through D+30 and 50% of the daily usage requirements from D+30 through D+60, has been established through a reduced production rate using limited soft tooling. Hard tooling, which is required to increase the production rate to 50% of the requirements, has an estimated acquisition lead time of 60 days. Therefore, full production begins at D+60.

Example: Assume that an inventory of 45,000 kits has been accumulated over a period of 450 days prior to D-day at a rate of 100 kits per day. This could be accomplished with soft tooling, which would not be suitable to make any significant contribution to the production of new kits during the contingency. For clarity, continued production with soft tooling after D-day is omitted.

2. Impact (Scenarios VI and VII). Full implementation requirements from D-day to D+30 are provided from inventory. Inventory must also be sufficient to meet 50% of D+30 through D+60 usage rate. Production rate on D+60 will be 50% of the daily usage rate. Procurement of materials (scenario VI) or hard tooling (scenario VII) for D+60 through D+90 production must be initiated at D-day.

F. Scenario VIII.

1. Description. Production during contingency is not planned. The 90-day contingency requirement was produced over a long period of time using soft tooling (see scenario VII) and maintained in inventory until D-day (figure 7).

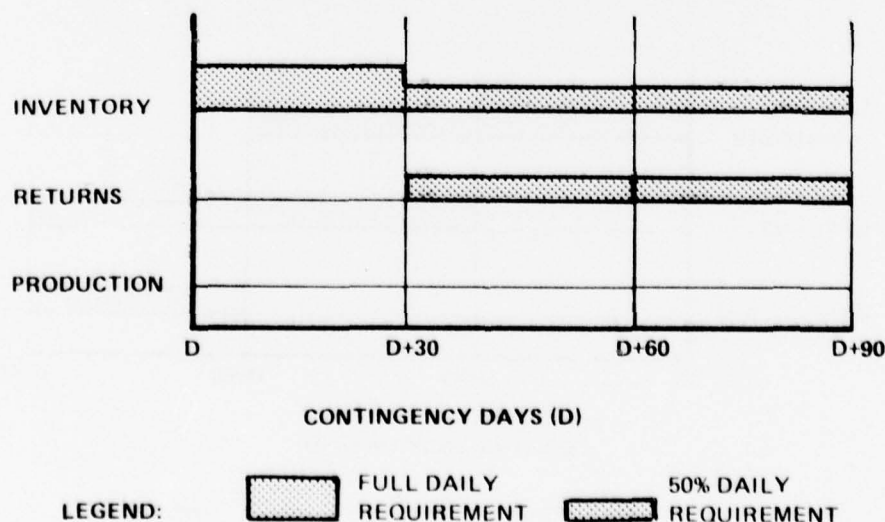


Figure 7. Time Flow Chart, Scenario VIII.

2. Impact. Full implementation is possible at D-day. The inventory must be sufficient to sustain daily usage requirements for the duration of contingency.

V. ANALYSIS

A. Basic Equation. The preceding scenarios illustrate how the daily requirements for a restraint system may be met from inventory of kits, kits produced during the contingency for immediate use, and, when applicable, returned restraint systems from previous shipments. This may be expressed by the equation:

$$N = I + P + R$$

Where:

N = The total daily usage requirement or supply

I = Daily inventory depletion rate

P = Daily production rate

R = Returned restraint systems

The following symbols will be used to denote specific periods during the contingency.

<u>SYMBOL</u>	<u>SIGNIFIES THE PERIOD FROM:</u>
A	Day 1 through 30
B	Day 31 through 60
C	Day 61 through 90

B. Calculations of "A" Period. Throughput requirements of 1,000 containers per day will be used (see table 2).

$$N_A = I_A + P_A + R_A$$

The R term in the basic equation is 0 during the "A" period since returns do not begin until the "B" period. Therefore, for this period the equation reduces to:

$$N_A = I_A + P_A$$

1. Scenarios I, II, and III.

$$N_A = I_A + P_A; \text{ but}$$

$$I_A = 0 \text{ since no inventory was maintained and}$$

$$P_A = 0 \text{ due to lead time requirements; therefore}$$

$$N_A = 0; \text{ i.e., no IRSKITS can be provided for these situations.}$$

2. Scenario IV.

$$P_A \text{ can be determined since tooling and materials are available.}$$

$$I_A = 0 \text{ since no inventory has been maintained; therefore}$$

$$N_A = 1000 = P_A; \text{ i.e., daily usage requirements are met through production.}$$

3. Scenario V. An inventory has been maintained and production is possible. Assume that both contribute equally to the daily requirement.

$$N_A = I_A + P_A \text{ or}$$

$$1000 = 500 + P_A; \text{ therefore}$$

$$P_A = 500; \text{ i.e., daily requirement is met by both inventory and production.}$$

4. Scenario VI, VII, and VIII. Production is blocked ($P_A = 0$), but an inventory of kits is available.

$$N_A = 1000 = I_A + 0$$

$$I_A = 1000; \text{ i.e., daily requirement is met totally from inventory.}$$

C. Calculations of "B" Period. (See table 2.)

$$N_B = I_B + P_B + R_B$$

1. Scenarios I, II, and III. The results for these scenarios are exactly the same as for the "A" period. Production is still blocked by the lead times for materials and/or tooling. No inventory was maintained at D-day, and returns ($R_B = 50\% N_A$) are nonexistent ($N_A = 0$). Therefore, due to the conditions imposed there will again be a shortfall of IRSKITS ($N_B = 0$).

2. Scenario IV.

$$N_B = I_B + P_B + R_B$$

$$N_B = 1000$$

$$I_B = 0$$

$$R_B = 50\% N_A = 500$$

$$1000 = 0 + P_B + 500$$

$$P_B = 500$$

3. Scenario V.

$$N_B = I_B + P_B + R_B$$

$$N_B = 1000$$

$$I_B = 0$$

$$R_B = 50\% N_A = 500$$

$$N_B = 0 + P_B + 500$$

$$P_B = 500$$

4. Scenario VI and VII.

$$N_B = I_B + P_B + R_B$$

$$N_B = 1000$$

$$P_B = 0$$

$$R_B = 50\% N_A = 500$$

$$N_B = I_B + 0 + 500$$

$$I_B = 500$$

5. Scenario VIII.

$$N_B = I_B + P_B + R_B$$

$$N_B = 1000$$

$$P_B = 0$$

$$R_B = 50\% N_A = 500$$

$$I_B = 500$$

D. Calculations of "C" Period. (See table 2.)

$$N_C = I_C + P_C + R_C$$

1. Scenarios I, II, and III. Production is possible during this segment, but $R_C = 0$ since there was a shortfall in the preceding segment ($N_B = 0$).

The equation becomes:

$$N_C = I_C + P_C + R_C$$

$$N_C = 1000$$

$$I_C = 0$$

$$R_C = 0$$

$$N_C = 1000 = P_C$$

2. Scenario IV.

$$N_C = I_C + P_C + R_C$$

$$N_C = 1000$$

$$I_C = 0$$

$$R_C = 50\% N_B = 500$$

$$1000 = 0 + P_C + 500$$

$$P_C = 500$$

3. Scenario V.

$$N_C = I_C + P_C + R_C$$

$$N_C = 1000$$

$$I_C = 0$$

$$R_C = 50\% N_B = 500$$

$$1000 = 0 + P_C + 500$$

$$P_C = 500$$

4. Scenarios VI and VII.

$$N_C = I_C + P_C + R_C$$

$$N_C = 1000$$

$$I_C = 0$$

$$R_C = 50\% N_B = 500$$

$$1000 = 0 + P_C + 500$$

$$P_C = 500$$

5. Scenario VIII.

$$N_C = I_C + P_C + R_C$$

$$N_C = 1000$$

$$P_C = 0$$

$$R_C = 50\% N_B = 500$$

$$1000 = I_C + 0 + 500$$

$$I_C = 500$$

VI. RANKING OF SCENARIOS

A. Effectiveness Ratio. From the data in table 2, it is now possible to establish a basis of comparison between the individual scenarios. An effectiveness ratio (E) will be formed to measure a scenario's actual performance versus the required performance.

$$E = \frac{\text{ACTUAL THROUGHPUT (N')}}{\text{REQUIRED THROUGHPUT}}$$

Since the maximum possible for any scenario is to satisfy the throughput requirements for 1000 containers per day for 90 days, we now have:

$$E = \frac{\text{ACTUAL}}{90,000}$$

The actual performance of a scenario would be the number of container loads which may be shipped under the conditions of that scenario. This may be determined from the flow charts or directly from table 2, "Throughput - Total (N')".

For Scenarios I, II, and III:

$$E = \frac{30,000}{90,000} = 0.333$$

For Scenarios IV through VIII:

$$E = \frac{90,000}{90,000} = 1.0$$

This was anticipated, since scenarios IV through VIII were developed to achieve full implementation by one method or another. Whereas scenarios I, II, and III were constrained to provide delayed implementation. Therefore, (E) can also be considered a measurement of readiness, with a value of unity (1.0) indicating readiness at D-day and values less than unity indicating either delayed implementation or a shortfall at some point in the contingency.

B. Examples of Reusability.

At this point two mini-scenarios will be introduced solely for illustrative purposes. These scenarios have been created to emphasize how reusability of the restraint system improves the effectiveness of a scenario. Since scenarios IV through VIII already have an effectiveness of 1.0 and maximize the reuse capability of IRSKIT, the remaining scenarios (I, II, and III) are used as the basis of comparison. These new scenarios will be equated to cost the same as scenarios I, II, and III, i.e., 30,000 kits but will be implemented earlier in the contingency.

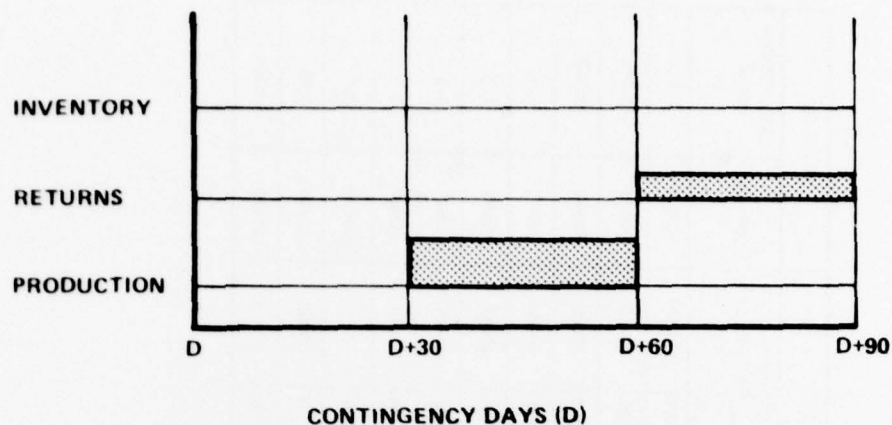
Essentially, the same 30,000 kits (and only that amount) which were not available until late in the contingency (Period C) in scenarios I, II, and III will be made available in earlier periods of the contingency.

The time flow charts are shown as figures 8 and 9 and tabulated results are listed in table 2, but the calculations are omitted.

1. Scenario X.

a. Description. Modified scenarios I, II, and III with lead times reduced from 60 days to 30 days. Stockpile contains materials for 30 days of full production (figure 8).

b. Impact. Full implementation only during "B" period and 50% implementation during "C" period.

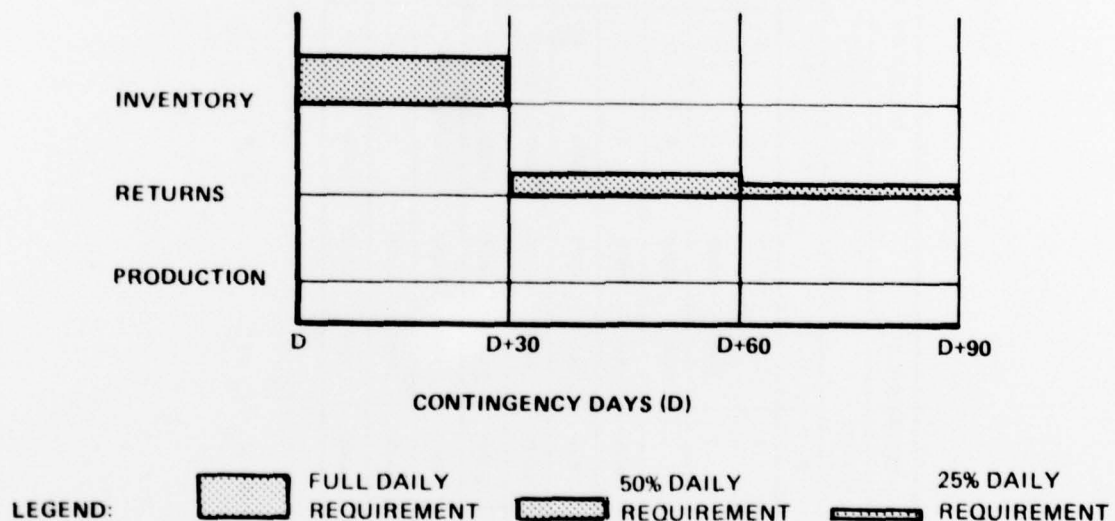


LEGEND:  FULL DAILY REQUIREMENT  50% DAILY REQUIREMENT

Figure 8. Time Flow Chart, Scenario X.

2. Scenario Y.

a. Description. Modified scenario VIII (figure 9) 30,000 kits in inventory. Contingency starts before full inventory (60,000 kits) has been obtained; no hard tooling or materials acquisition initiated.



LEGEND:  FULL DAILY REQUIREMENT  50% DAILY REQUIREMENT  25% DAILY REQUIREMENT

Figure 9. Time Flow Chart, Scenario Y.

b. Impact. Full implementation only during "A" period; 50% during "B" period and 25% during "C" period.

Table 2

SCENARIO	THROUGHPUT			INVENTORY REQUIRED			PRODUCTION			RESULTS	
	PERIOD			PERIOD			PERIOD			COST (Q)	EFFECTIVE-NESS (E)
	A	B	C	A	B	C	A	B	C		
I	0	0	30000	0	0	0	0	0	30000	30000	0.333
II	0	0	30000	0	0	0	0	0	30000	30000	0.333
III	0	0	30000	0	0	0	0	0	30000	30000	0.333
IV	30000	30000	30000	0	0	0	30000	15000	15000	60000	1.0
V	30000	30000	30000	15000	0	0	15000	15000	15000	45000	1.0
VI	30000	30000	30000	30000	15000	0	0	0	15000	60000	1.0
VII	30000	30000	30000	30000	15000	0	0	0	15000	60000	1.0
VIII	30000	30000	30000	30000	15000	15000	0	0	0	60000	1.0
X	0	30000	15000	0	0	0	0	30000	0	30000	0.50
Y	30000	15000	7500	30000	0	0	0	0	0	30000	0.583

LEGEND:

$$N' = 30 \times (N_A + N_B + N_C)$$

$$P' = 30 \times (P_A + P_B + P_C)$$

$$E = N' \div 90000$$

$$I' = 30 \times (I_A + I_B + I_C)$$

$$Q = I' + P'$$

The results of these two mini-scenarios are included in table 2 for ready reference and comparison with the other scenarios. It has been earlier stated that as E approaches or equals unity ($E = 1.0$), readiness from D-day is increased, i.e., Scenario X; $E = 0.50$ and Scenario Y; $E = 0.583$. However, it should be again noted that the cost (Q) was the same as for Scenarios I, II, and III which had $E = 0.333$. This is solely the result of reuse. In effect, the earlier implementation of X and Y permits 30,000 kits to do the work of 45,000 or 52,500 (N') units respectively.

C. Relative Cost of Scenarios. When comparing the scenarios, the relative cost (or cost difference, if any) must be determined. The primary cost variables among all scenarios discussed herein lies in: (1) the amounts of materials consumed (in the form of kits or a stockpile of kit-set equivalents) and (2) the tooling required.

1. Materials Required. There appears to be no difference in the material requirement for any of the full implementation scenarios. This is true for materials where stockpiled as "kit equivalent sets" or actual kits in inventory before D-day. This also applies to materials procured for in-contingency production to be fabricated and installed into containers directly. Table 2 ($Q = I' + P'$) shows that 60,000 kits (or equivalent materials) will provide full and immediate implementation.

The following chart (figure 10) has been derived from table 2 and is a graphic representation of the full implementation scenarios (IV through VIII). All have the same material cost ($Q = I' + P'$) since the same total quantity of kits (60,000) is involved.

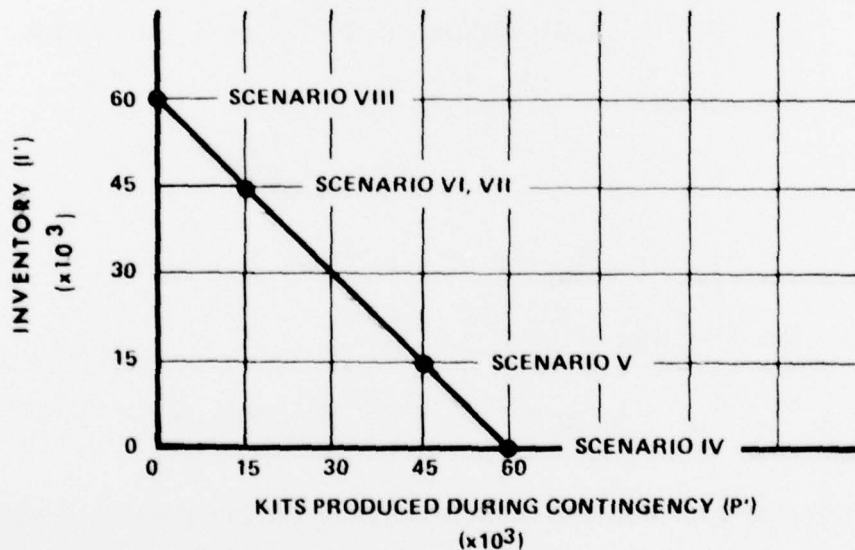


Figure 10. Full Implementation

It can be shown that any other scenario which falls on a line connecting the points (i.e., combinations of I' and P' which total 60,000) will also provide full implementation. However, construction of the actual scenario and its flow chart may be somewhat more complex than heretofore shown.

2. Tooling. At this point, the subject of tooling and the manner by which it relates to the scenarios will be examined. Table 3 lists the tool type required and periods of usage. Tooling requirements are related to production requirements and will for estimating purposes be taken to be directly proportionate to the production rate.

Referring to the preceding material (figures 3 through 7, table 2 and section V) two in-contingency production rates appear. These are 500 and 1000 kits per day (equivalent to 50% and 100% of full daily requirement or 15,000 kits and 30,000 kits per contingency period). Assigning a value of one tool set to that quantity of equipment needed to produce 500 kits per day, than two tool sets would be required in order to produce 1000 kits per day.

A ratio may be formed from which the utilization of hard tooling by a scenario may be measured and compared to the other scenarios. This ratio (T_u) will be formed using the quantity of tool sets (T_r) and the quantity of kits produced by that quantity of tooling. This ratio takes the form of either:

$$T_u = \frac{T_r}{P_r} \text{ or}$$

$$T_u = \frac{T_r}{Q} \text{ depending on the scenario constraints.}$$

For scenarios I, II and III

$$T_u = \frac{T_r}{P_r}$$

$$T_u = \frac{2}{30000} = 0.67 \times 10^{-4} \text{ tool sets per kit}$$

For scenario IV

$$T_u = \frac{2}{60000} = .033 \times 10^{-4} \text{ tool sets per kit}$$

even though one of the tool sets will be surplus during periods B and C.

For scenario V, $T_r = 1$ which was used in the pre-contingency to fabricate the inventory (I') of 15,000 kits.

$$T_u = \frac{T_r}{Q} \quad \begin{array}{l} I' = 15000 \\ P' = 45000 \end{array}$$

$$= \frac{1}{60000} = 0.17 \times 10^{-4}$$

Scenario VI yields the same result as scenario V due to a longer pre-contingency production and therefore, a larger inventory from hard tooling which is subsequently used for a smaller in contingency production.

Scenario VII utilizes both soft as well as hard tooling. Disregarding the soft tooling, the tool utilization factor (T_u) for the hard tooling may be calculated as:

$$T_u = \frac{T_r}{P'} = \frac{1}{15000} = 0.67 \times 10^{-4}$$

Scenario VIII does not require hard tooling, and therefore, a utilization factor is not applicable.

It is apparent that the lowest values of T_u indicate the scenarios which utilize hard tooling to the greatest extent.

Table 3.

SCENARIO	TOOLING TYPE		CONTINGENCY PERIODS				TOOLING SETS REQ'D (T_r)	TOOL UTILIZATION ($T_u \times 10^{-4}$)
	SOFT	HARD	PRE D-DAY	A	B	C		
I	-	X	-	-	-	X	2	0.67
II	-	X	-	-	-	X	2	0.67
III	-	X	-	-	-	X	2	0.67
IV	-	X	-	X	-	-	2	0.33
	-	-	-	-	X	X	1	
V	-	X	X	X	X	X	1	0.17
VI	-	X	X	-	-	X	1	0.17
VII	X	-	X	-	-	-	0	0.67
	-	X	-	-	-	X	1	
VIII	X	-	X	-	-	-	0	NA

The time flow charts (figures 3 through 7) were previously used to graphically describe the sources for in-contingency usage and to determine requirements. Similar charts also are useful for showing pre-contingency production based on availability of tooling. Figures 11 through 14 show scenarios V through VIII. Scenarios I, II, III and IV are omitted since no pre-contingency production is involved. It should be noted that pre-contingency production is shown as commencing on D-day minus the number of days that the level of tooling allows to accumulate the inventory of complete kits for each scenario. Actually, this pre-contingency production could occur in any other period of equal length prior to D-day, i.e., for scenario V (figure 11) the production could take place from D-77 to D-47, or from D-61 to D-31, etc.

3. Residual Value. If each scenario could be represented by an accounting ledger sheet, all expenditures for materials and tooling would be classified as debits. The credit side of the ledger would carry the salvage value in the event that a contingency never arose, or if higher technology made IRSKIT obsolete before it was ever utilized.

The IRSKIT system consists of standard hardware and modified basic materials. The standard hardware (nuts, bolts, washers, shackles) constitutes about 15% of the cost of a complete system. This portion would retain its marketability since it remains as purchased and it could probably be disposed of at a later date at close to the original purchase price. This also applies to the stockpile of basic material for in-contingency production. Inventories of complete kits containing machined and finished components would probably have little value other than as scrap metal and the 15% standard hardware portion. Any special tooling or fixturing is not expected to retain more than scrap value, but standard machinery such as drill presses, grinding machines, etc. would retain close to their full value in the same manner as discussed above for standard hardware and basic material. However, no estimated percentages can be given at this time.

Table 4 summarizes the above as well as reviews the expenditures required by each scenario.

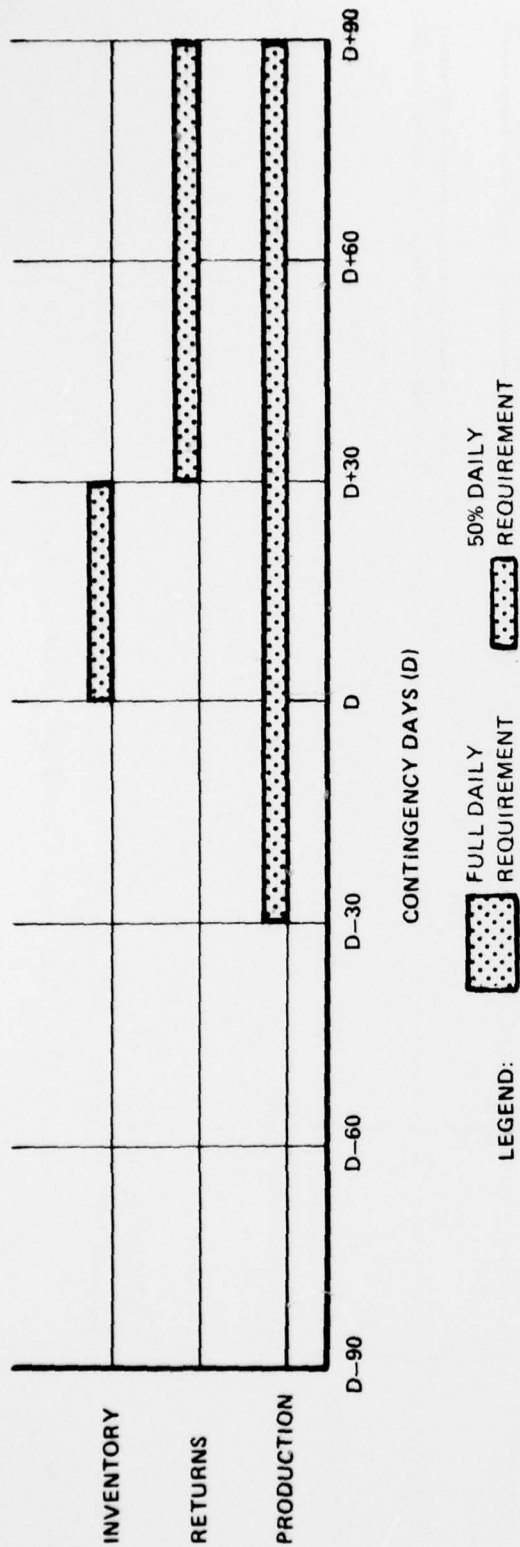


Figure 11. Expanded Time Flow Chart, Scenario V.

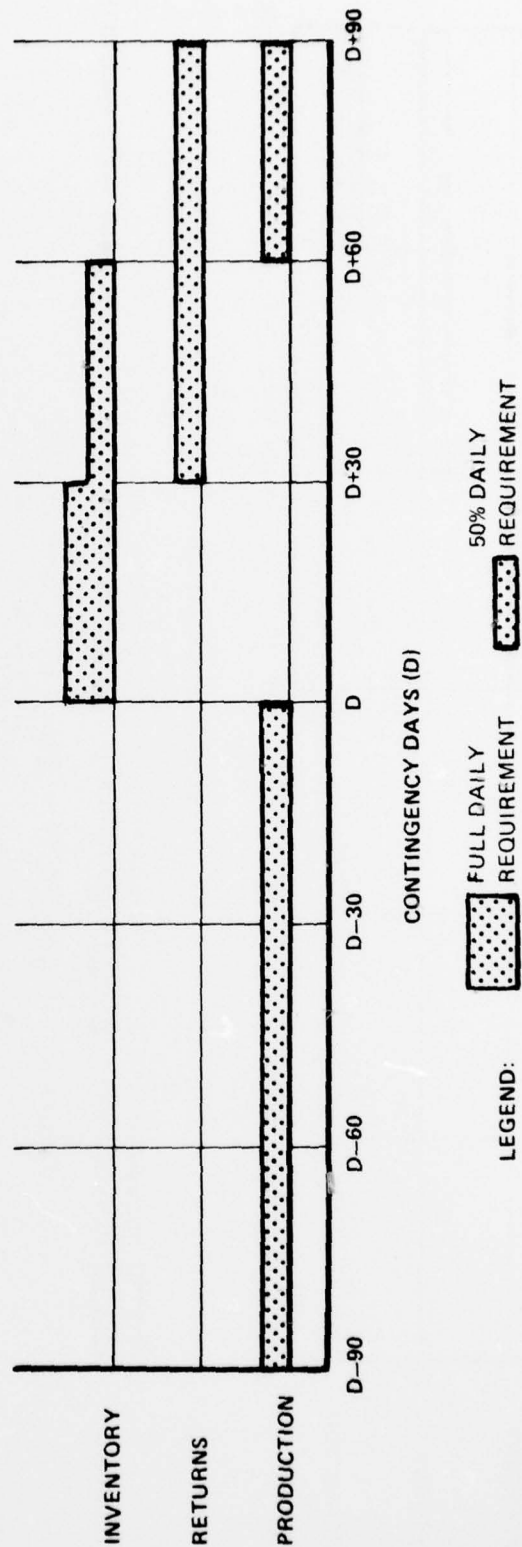


Figure 12. Expanded Time Flow Chart, Scenario VI.

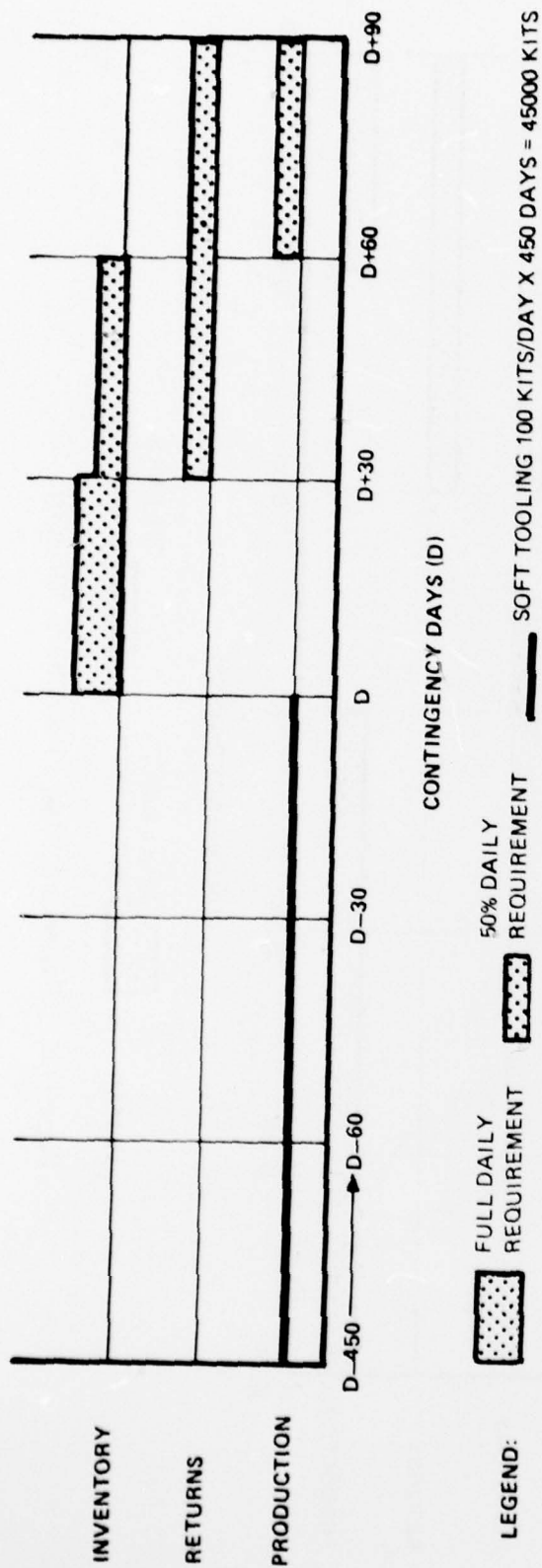


Figure 13. Expanded Time Flow Chart, Scenario VII.

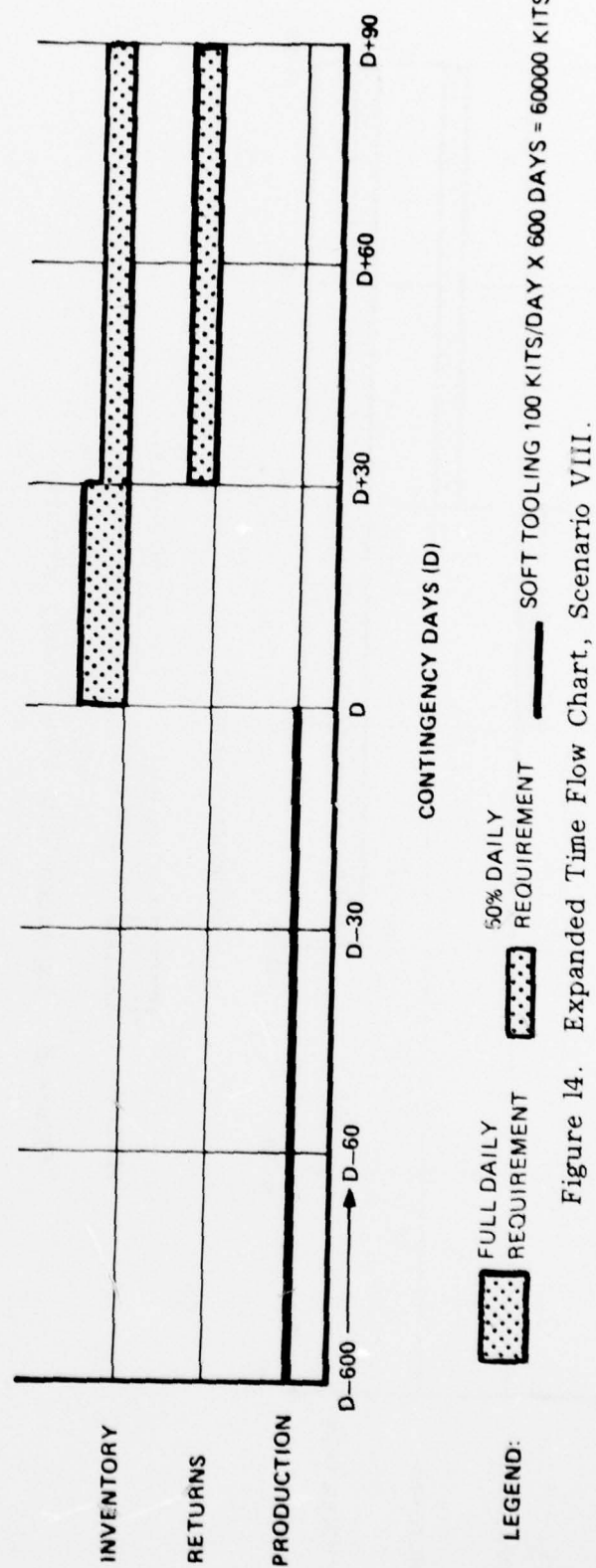


Figure 14. Expanded Time Flow Chart, Scenario VIII.

Table 4.

SCENARIO	EXPENDITURE					*RESIDUAL VALUE
	PRE-CONTINGENCY			CONTINGENCY		
	TOOLING	MATERIAL STOCKPILE	KITS INVENTORY	TOOLING	MATERIAL	
I	0	0	0	2	30000	0 tool sets 0 stockpile 0 kits
II	2	0	0	0	30000	2 tool sets 0 stockpile 0 kits
III	0	30000	0	2	0	0 tool sets 30000 stockpile 0 kits
IV	2	45000	0	0	15000	2 tool sets 45000 stockpile 0 kits
V	1	30000	15000	0	15000	1 tool set 30000 stockpile 15000 kits
VI	1	0	45000	0	15000	1 tool set 0 stockpile 45000 kits
VII	0	15000	45000	1	0	0 tool sets 15000 stockpile 45000 kits
VIII	0	0	60000	0	0	0 tool sets 0 stockpile 60000 kits

*Contingency never occurs.

VII. SUMMARY AND SCENARIO RECOMMENDATIONS

Herein presented is a procedure for analyzing and evaluating readiness and implementation options pertaining to a restraint system for transporting ammunition in commercial intermodal containers. This procedure might also apply to other types of equipment containing similar elements. Some of the elements considered were reusability, in-contingency production, lead time, material stockpile and kits inventory.

Simplified scenarios containing these elements have been constructed in an effort to minimize complexity while maintaining clarity. The approach taken is judged to be straightforward and suitable for refinement or expansion if desired.

Before a recommendation is made regarding scenario selection, it is acknowledged that budgetary and program completion goals have not been included. These and other factors would have a considerable bearing on the final selection of a scenario. For instance, if readiness requirements were less than 1 year away, scenario VIII would not be a viable one due to its long period of inventory accumulation. Budgetary constraints could restrict the inventory of large quantities of kits for a contingency which may never occur. If this were so, then scenario VIII would be subject to elimination. Scenarios VI and VII could also be eliminated since they also present large inventory requirements and gain little from in-contingency production. Accordingly, each of the full implementation scenarios (IV through VIII) may gain or lose appeal in areas beyond the scope of this study.

Evidently, the "broad brush" treatment taken is not wide enough to cover the foregoing. Yet it is too broad to reveal the finer distinctions between the scenarios. The discussion of the scenarios has centered on material and tooling since these are reflected in the throughput capabilities. Other requirements have been omitted but they do exist and should be mentioned. Several of these would be transportation, warehousing, personnel resources and training. It is assumed that in a contingency adequate amounts of everything could be obtained. The point is that quantities and timing of these ancillary requirements should undergo a similar examination in a scenario framework as did materials and tooling.

Returning to the analysis of the full implementation scenarios it is recommended that a moderating approach which uses a combination of initial sources (inventory and in-contingency production) as described in scenario V be adopted.

This requires an inventory first of all. Of all the scenarios requiring initial inventory, scenario V requires the lowest commitment (table 2). That inventory does not have to be in the form of crated, stored and previously unused kits as herein depicted. Rather, these 15000 kits could represent the "controlled" portion of a somewhat larger total quantity, some of which are installed in containers and in use. The "controlled" portion represents the minimum number which is always retained CONUS, available for ammunition shipments.

Scenario V's inventory would have been fabricated in the pre-contingency with the one set of hard tooling as required for in-contingency production. When this production run for inventory is completed, the hard tooling could then be placed in storage along with a materials stockpile. Both tooling and materials would be removed from storage at D-day to commence in-contingency production. As indicated by the tool utilization factor (T_u , table 3) scenario V makes optimum use of its tooling. Scenario VI also achieves the same tool utilization. However, scenario VI incurs a large inventory of kits which would be a disadvantage in terms of residual value (table 4). Scenario V has the added advantage of a uniform continuous in-contingency production run.